Optimal Design Report
Vital Signs Monitor
By
Maysarah Shahabuddin, David Knoff, and Jacob Adams
Team No. 5
Client: John Enderle, University of Connecticut, (860) 486-5521

1. Introduction

Our group's interpretation of how best to organize this project suggests that the simplest design is the best. As any engineer should know, the less complicated something is, the less things that can break. We have decided that the best way to organize the vital signs monitor is to minimize the number of components to the bare minimum. This means that each sensor will be a part of a whole as opposed to being individual devices sharing only proximity. For a device that intends to provide a comprehensive look into the human body, we can do an optimal job of this by minimizing the sensors and stripping them of their luxuries. This way we can get rid of one Bluetooth module for each sensor, as well as remove the need to replace/charge several batteries. By separating everything, we can work backwards from the "the whole is greater than the sum of its parts" philosophy, and make each part an individually smaller portion that sums to the original whole.

The chest strap will be sweat resistant, elastic, soft, breathable material on the side closest to the body. On the other side, facing away from the patient however, there will be a few "rails" of open electrically conductive strips running parallel to each other throughout the length of the strap. (See Figure 1)There will be another soft elastic thin secondary layer designed to cover and protect the user, and these open wires from each other. The purpose of these striped wires will be to provide a ground, a power source, and a data channel. Connecting to each of these wires will be a box to which the chest strap originates. This box will be worn such that it will lie between the scapulae, and not impede any daily function of the user. This box will provide power and ground along two of the three parallel stripes. The third will be a data wire used to communicate between sensors and the main strap computer. These boxes will then take all of the data (communicated via a wired connection), consolidate it into a signal, and communicate via a Bluetooth chip to whatever base station or LabVIEW enabled device of one's choosing. The rails will provide power, and a means of communicating to the chest strap box, which will carry the brunt of the data processing load.

The sensors then will be used by clipping in between the two separate layers such that conducting pins will connect and provide power to each individual sensor (see Figure 2). A third pin will then be used to communicate the single channel of data to the box. Communicating multiple sources of data on a single wire can be accomplished using the 1-Wire communication protocol developed by Dallas Semiconductors, or the I2C communication bus developed by Phillips. Either communication method is compatible with Arduino microcontrollers via existing API, however I2C is built into the existing library possibly making it easier to use. Each sensor will be programmed to handle its own input, translate it into a language communicable via this single wire that can provide, and then communicate to the main box on the chest strap back. This reliable method of data transfer will offer built in support for a variable amount of sensors (if two temperature sensors are needed for example) because each sensor will have its own unique serial number so the same type of data won't confuse the microcontroller. The main box will then take each of the sensors data, and prepare it for interpretation by the existing circuitry, and LabVIEW. Ultimately the presence of three wires in the strap may or may not be necessary, dependent on whether we use this communication method or not. Since it is low power and low speed, the novelty of minimizing the expose wires will need to be addressed.

This system is efficient for several reasons. It will be cheaper to produce, lighter, user friendly, and customizable. It will be cheaper to produce because each sensor will be small, and lack complicated communication relay, or batteries. Due to the lack of batteries in each device, the total weight of all sensors will be minimized, adding to the comfort of the user. The modular

nature of each sensor means that replacement of faulty parts is simple. Either replace the main battery, or a cheap sensor module, not both. Diagnosing such problems will be incredibly easy since either all parts are powered, or just one is not relaying data, or no data is being interpreted, but power is being sent to them. Troubleshooting will essentially be reduced to ensuring the proper contacts are maintained, and placing the sensors (which by attaching via clips, are variable in their placement) in the proper locations. From there, it would be easy to isolate which, if any, parts are not working. Since the wires run across the entirety of the strap, sensor position can be adjusted for any patient by clipping each of them wherever they may be optimally positioned on their body. Finally it is customizable by allowing doctors to purchase only specific sensors. Each one will be self-contained, and will be able to run independently of other sensors.

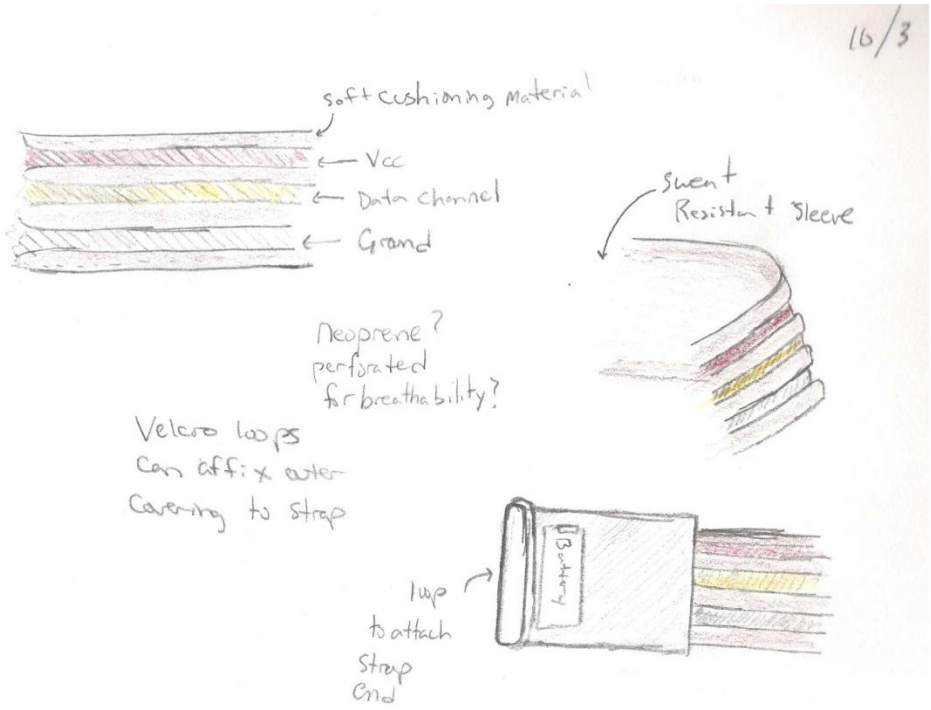


Figure 1: Strap containing rails.

2. Subunits: (progress: 7/10)

2.1 Strap (half a page)

We chose to use a strap similar to spandex because this lightweight breathable material is commonly used in similar applications, such as for holding existing sensors close to the body or binding splints along bodies for extended periods of time. This has a major benefit because there is existing proof that this will work well in a wide variety of patients. The strap will be embedded with 4 bare strips of flatwire. We chose flatwire because the open copper wire will provide a flexible and conductive pathway for signals and power to travel. There will be 4 pathways because there are two needed for power and ground respectively, while the two middle pathways will be for I2C Clock signal, and I2C Data Signal. I2C works by using the clock data to choreograph when each bit is sent from each sensor connected in parallel between the wires. The clock channel will also send activation to the listening sensors. Since each sensor will not send data unless it is its "turn" we can use the activation as a trigger for a power save mode. Once the master requests that the sensor start sending data, the sensor can take a moment to begin drawing power, take measurements, send data and then stop and enter a low power state once the stop bits have been received. A limitation to I2C is that the data cannot be transmitted simultaneously from multiple sensors, however with a data transmission rate of around 100 kHz, and a relatively low volume of data, this is unlikely to be a problem. The strap will be connected at one end inside the master controller box, and the other end will loop through a hook on the other end of the box to be cinched, where a simple Velcro strap may be used to fasten it around the user at their comfort.

2.2 Main Controller (half a page)

The main controller box will use a more powerful microcontroller than any inside the sensors and will coordinate the communication from the sensors to the LabVIEW. This will involve programming revolving around two modes of communication. The main box will first take the I2C data received from all the sensors. This microcontroller will be the master responsible for taking and requesting data from the sensors and then send it to Bluetooth. Finally this controller must have some method of determining how many sensors are to be placed on the strap. This is so the serial data collection can occur enough times to cover each sensor. This might be implemented by LabVIEW or an interface on the box itself.

2.3 Temperature sensor

This small device will clip on the chest strap and be placed in the armpit. This is the closest location for core body temperature that will be accessible to the chest strap. The inside of the clip will have three contacts for the power, ground and data transmission. This sensor will be the simplest to develop communication for. A resistance temperature detector (RTD) placed in contact with the inside of the armpit will ensure constant contact and an accurate data reading. This thermistor will change in resistance as temperature changes. This change in resistance can be sensed by the microcontroller based on the voltage drop across the RTD, which can then interpret, and perform a simple calculation to convert the signal to degrees Celsius and degrees Fahrenheit. Alternatively the raw resistance data can be communicated and be calculated by LabVIEW. The size of the data needed to be transferred by this sensor is relatively small and should only take a small amount of bandwidth.

The temperature biosensor will use an OMEGA Thin Film RTD Element/Probe to record the patient's body temperature. This product was selected because of its high ratio of surface area to volume, high surface conductivity, flat platinum resistance detector design, fast response time and low cost ($25-$75). This RTD complies with DIN 43760 and BS 1904 resistance and tolerance standards which requires platinum wires to have a temperature coefficient (α) of +0.00392 Ω/Ω/˚C and a tolerance of .06% @ 0˚C for class A RTD's. The response time of the OMEGA Thin Film RTD is under a minute in air moving at 1 m/s. Our application of this device will be in still conditions under the armpit, suggesting that the response time may be even quicker. The expected patient body temperature resides well within the RTD temperature range which resides between -70˚C (-95˚F) and 500˚C (930˚F). The final resistance can be calculated for temperatures above 0˚C by using the equation:

$$Rt=R0(1+At+Bt2)$$

Where A=3.90833 x10-3 (C-1), B=-5.7753 x10-7 (C-2), R0 is the resistance at 0˚C, and t is the temperature.

Thin film RTD elements work by placing platinum resistive material on a ceramic substrate and coating it in an epoxy or glass. The coating helps protect the platinum wire from shock, vibration, deformation, and strain. One disadvantage to thin films are they are less stable than wire wound or coiled RTD elements, however its form is beneficial to our chest strap design by making the biosensor less bulky without sacrificing the overall function of the RTD significantly.

The body temperature biosensor circuitry will consist of a 4-wire bridge to eliminate lead impedance which can create error in the temperature measurement. Figure 2 shows the RTD sensor circuit with RT representing the RTD resistance, RL and RL2 represents the resistance of the long wires, and R1-R3 represents the other resistances in the wheatstone bridge. The RTD is distanced from the rest of the circuit to reduce heat exposure to the remainder of the circuit which may change other resistor values and create error.

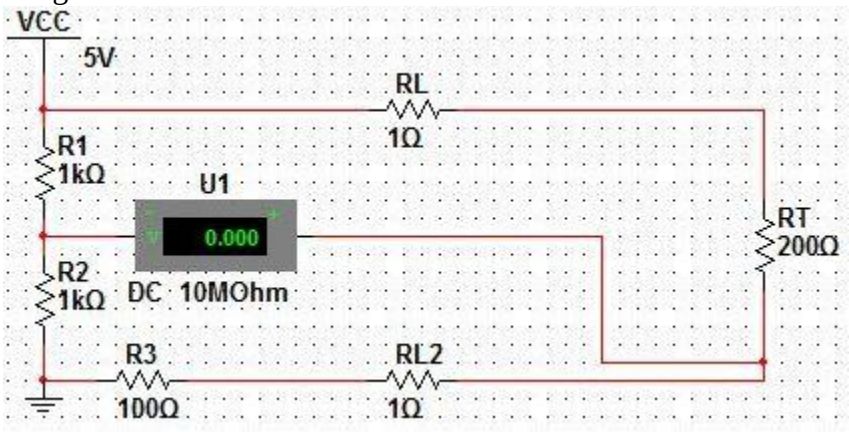


Figure 2: RTD Sensor Multisim Diagram

The voltmeter represents the output data of the temperature biosensor which is then processed by LabVIEW. Using the output voltage, LabVIEW will process the data to find the final resistance of the RTD and evaluate the patient's body temperature by comparing the final

resistance to the initial resistance as seen in Figure 3.

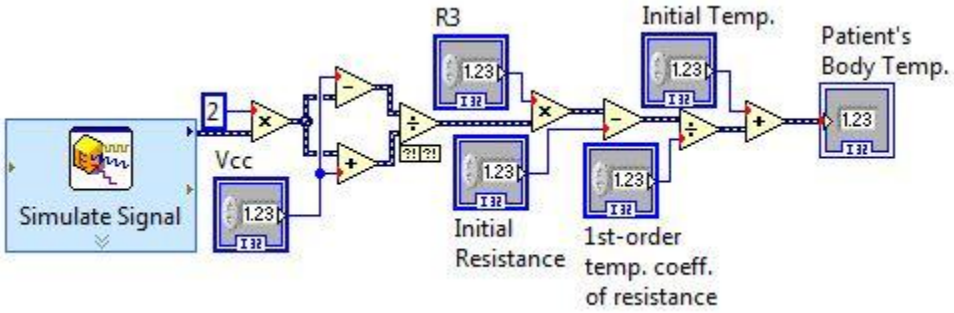


Figure 3: Temperature Biosensor LabVIEW Programming
The simulated signal represents the signal sent from the body temperature biosensor. Once processed, the final output displays the user's body temperature to the user on their Microsoft Surface tablet.

2.4 Blood Oxygen monitor

Pulse oximetry is the measure of blood oxygen content using the optical properties of hemoglobin. Oxygenated hemoglobin absorbs infrared light and lets red light pass through, while deoxygenated hemoglobin displays the opposite properties. Pulse oximetry is thus accomplished by shining a red and an infrared light through a translucent part of the body, useful contact points for this are the finger, palm, toes, soles, the earlobe, and the tip of the ear (Jyotirmoy Das et al.) Opposite to this point is a light detector that detects the light that has passed through the thin section of the body. After the sensor detects this, a computer calculates the ratio of absorbed red to absorbed infrared light ratio as shown in fig. 4.

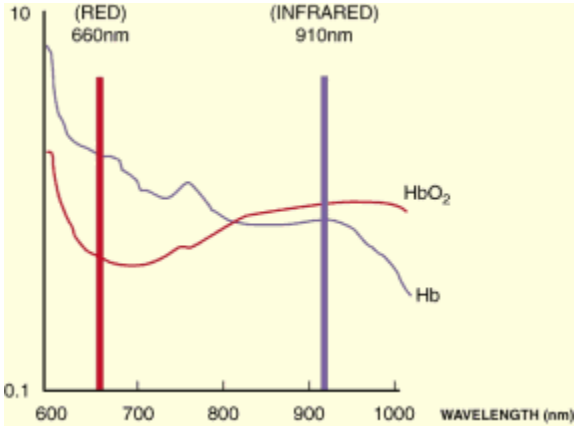
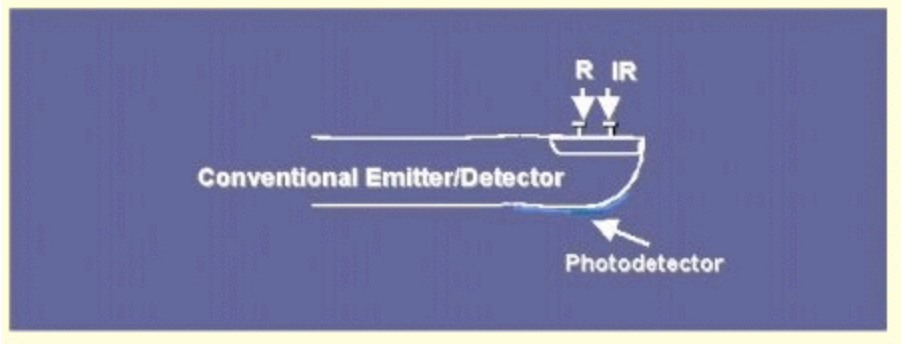


Figure 4: Absorbency of red light to infrared light

Upon obtaining this ratio, the software can then consult a table of values, usually from reference, or calibration data, to determine the blood oxygen content ratio. There are two placements of sensors for detection, transmittance and reflectance. In transmittance, the sensor sits opposite to the light sources, and the absorbance is calculated dependent on the light that passed through the skin.



In reflectance, the sensor is placed on the same side as the light sources, and the light that is returned is used to obtain measurements. Since the two methods require two different theories behind operation, a decision needs to be made regarding whether transmitted or reflected data should be used. This will affect the calibration data needed to determine blood oxygen content.

This sensor will be designed differently from the others. Whereas the other sensors have the option of picking up singular point of data and sending it along the wire to the Bluetooth transmitter, this sensor will require more processing power, and depending on the kind of data sent, more memory on board. A blood oxygen monitor needs two different LEDs to shine through a thin portion of the patient's skin, in this case, the earlobe. A detector then picks up the light that has shined through the patient and a ratio comparing the two absorbance's must either be calculated on the sensor itself, or be sent to the controller, dependent on the limitations provided by the microchip on board, and the requirements of the I2C communication protocol. This is then plugged into a function, or compared the absorbance curve based on standard data to determine the blood oxygen content in the blood. In this design, it would be sensible to place a sensor box on the patients back, and have a wire that contains the clip with two LED's and the one photosensor snaking up under the shirt to the patients earlobe. This thin area of the body also serves as a good location for pulse oximetry compared to the finger, and has the added benefit of being very near the chest strap. A small cable no longer than 10 inches will be all that is needed to ensure that the signal can be obtained by the sensor wherever it is placed. The earlobe clip will need to have power going to both sides, with just a power and a ground wire for the lights, and a third wire for the photosensor. We will be using a light to frequency converter to subvert some of the calculation. Once that data is sent directly to the chip, the ratio and then blood oxygen content can hopefully be transmitted to the controller box.

2.5 Fall detector

In interest of keeping as many sensors as close to the chest strap as possible (to remove the hassle of peripheral devices), the fall detection biosensor will use a triple axis accelerometer attached to the chest strap to detect abnormal three dimensional motions. As opposed to extremities such as the arms or legs, the core of the patient's body will only have a drastic change in motion and positioning during a fall. Extremities will have constant change in motion and positioning during daily activities. The triple axis accelerometer being placed on the chest strap allows the fall detector biosensor to evaluate the patient's stability closer to their center of gravity which should allow for more accurately identifying when the patient falls. The data sent by the fall detection biosensor will be calibrated to prevent a false identification of a fall and allow proper evaluation of abnormal movements in the patient's center of gravity. The triple axis accelerometer detects proper acceleration, or acceleration relative to free fall, in all three axes of movement. After processing the data using a microchip to determine whether abnormal

motion occurred, a simple binary output will be sent to the LabVIEW program which will indicate a fall if true or normal movement if false.

In order to continuously monitor the patient to detect a fall at any point, the fall detection biosensor will need to draw a minimum amount of power continuously in order to power the accelerometer and microchip. Minimizing the energy consumed by the fall detection biosensor will ensure our goal of creating an efficient and environmentally responsible vital signs monitor. In order to meet these design requirements, the fall detection biosensor will use the ADXL335 triple axis accelerometer made by Sparkfun Electronics (Boulder, CO) seen in Figure 5.

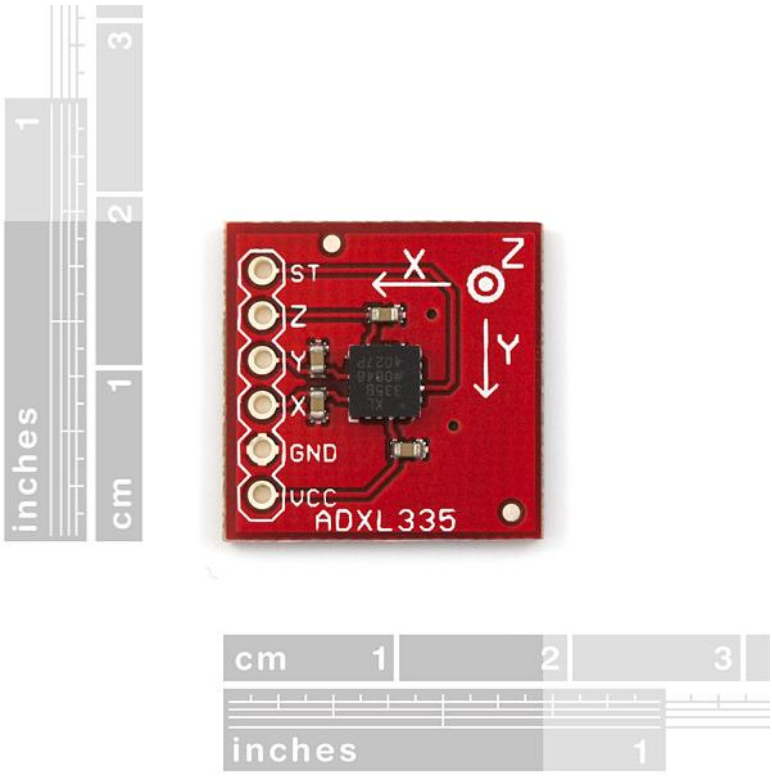


Figure 5: Sparkfun Electronics ADXL335 Triple-Axis Accelerometer

This product is attractive to our design specifications because it only consumes 320 uA of power, it diminishes noise, its dimensions are a mere 0.7'' x 0.7'', and it has a full sensing rage of +/- 3g. One limitation includes the need for a lower voltage power supply to the accelerometer. If we assume the power line of the chest strap has a voltage of 5 V, there will need to be a voltage drop in the circuit to accommodate the accelerometer's desired voltage range of 1.8-3.6VDC.

Based on the previous design of the vital signs monitor, only one output of data from a biosensor can be received at a time. In order to have the fall detection biosensor constantly monitoring without using the data transmission line, the output of the biosensor must only transmit data in the case of a fall, rather than continuously occupying the line.

2.6 Stethoscope

Stethoscopes are useful tools in the medical industry as they can listen to lung activity and/or heart activity. There are many types of stethoscopes that are used to perform this function which are, but not limited to: contact microphones, pressure sensors, mechanical stethoscope, and electronic stethoscope. The best choice for the Vital Sign monitor would be the electronic stethoscope as it can generate a signal to be processed and transmitted via Bluetooth to the Microsoft Surface tablet. Signals from this electronic stethoscope can be amplified and filtered easier than other types of stethoscopes. Electronic stethoscopes already cancel out noise at about 80% which could be filtered more in the LabVIEW program but there might not be a need for it.

Electronic stethoscopes will fit the design of the strap and will utilize the 1-Wire communication protocol that handles the supply voltage and ground as well as communication to the microcontroller on the back of the strap and the Bluetooth device. Also, since many products already exist in the market, they can be purchased on an as needed basis or perhaps be an option of the VItal Sign product, which could lower the overall cost of production of the entire product. However, if an electronic stethoscope doesn't clip onto our strap, that could present a problem. Our group will include an already made stethoscope in the product. Current products on the market include 3M™ Littmann® Electronic Stethoscope Model 3200 which already has Bluetooth capability but is costly, while a Master Classic II™ Stethoscope would suffice as it is cost effective and has no Bluetooth transmitter, which will work better in the overall design of the strap. Figure 6 below is the 3200 model while fig. 7 is the Master Classic II™. If there are more cost effective models out there we will find those.

Figure 6: 3M™ Littmann® Electronic Stethoscope Model 3200 with Bluetooth capability.

Figure 7: 3M™ Littmann® Master Classic II™ Electronic Stethoscope

Either of these electronic stethoscopes can be fitted with a clip that will attach to the main device. They are both removable sensors from the overall stethoscope which includes wiring and headphones, so we will only include the removable sensor included in the device package. We will also provide a user manual for whichever stethoscope makes the most sense economically and functionally. The output of the electronic stethoscope will be sound from the Microsoft Surface with the block diagram that will convert this signal.

2.7 Scale

Patient's weight is going to be accounted for but not included in the strap design as it would be impossible to gain a measurement of weight of the patient through the strap. Therefore, there are two options we can go about solving this problem. The overall product will either include a Bluetooth enabled scale, which there are such devices on the market, or take a scale and fit it with a Bluetooth transmitter and microcontroller. I think that given patient's budget, they should have the option to purchase a separate Bluetooth enabled scale to lower the overall bundle cost of the product. An example of a premade scale is shown in fig 8.

Figure 8: This Bluetooth enabled scale is a product of A&D Medical UC321PBT Precision Scale and costs $188

3. Realistic Constraints: (2pg min)

One of the constraints for this project is power consumption. Hopefully most of the sensors are relatively low in their power consumption, and the I2C protocol has some built in ways to trigger a "power save" mode for sensors when they are not collecting data. However, for the pulse oximeter, a relatively high amount of energy needs to be provided for the light emittance, and then subsequent calculation of data. There is no way to tell whether or not it would be possible to supply a table of values for comparison. Ideally a function can be used to model the absorbance to oxygen content relationship, and a simple calculation will be all that is needed. As of the current stage, without more experience with the programming, it is difficult to tell whether or not the existing microchips will be able to handle the load of interpreting and calculating a ratio. If this is done on the sensor itself, this calculation may tax the microchip since we aim to use low power, low cost chips, (depending on the complexity). If due to the way I2C works, we need to send it already processed, then we might need to use a more powerful chip, in which case the concerns for the straps ability to provide power to all of the sensors still stands, and may even be cause for more concern. The design of the sensors to distribute their software amongst different outlets may work to our advantage since we have the option of performing some calculations in one of three places, either the onboard microchip on the sensor, or the controller box, or finally for the most intensive of tasks, we can send raw data to LabVIEW to interpret and organize for us. The largest obstacle for the blood oxygen content sensor is that at the very least, the frequency data needs to be compiled into a singular ratio before sent to a computer across Bluetooth because the existing Bluetooth program was not created to accept multiple points of data.

In order to continuously monitor the patient to detect a fall at any point, the fall detection biosensor will need to draw a minimum amount of power continuously in order to power the accelerometer and microchip. Minimizing the energy consumed by the fall detection biosensor will ensure our goal of creating an efficient and environmentally responsible vital signs monitor. Based on the previous design of the vital signs monitor, only one output of data from a biosensor can be received at a time. In order to have the fall detection biosensor constantly monitoring without using the data transmission line, the output of the biosensor must only transmit data in the case of a fall, rather than continuously occupying the line. The Sparkfun Electronic's ADXL335 Triple Axis Accelerometer needs the power supply to exist in the range of 1.8-3.6 VDC which creates the need to make a voltage drop from the chest strap Vcc power line if it is above the given voltage range.

The temperature biosensor includes a thin film RTD which requires several constraints in order to perform accurately and efficiently. Voltage above 100Vdc will destroy the thin film RTD element. The RTD element must be separated from the other circuit elements which may increase in temperature to avoid self-heating error. The minimum and maximum temperature the RTD can measure are -70˚C (-95˚F) and 500˚C (930˚F) respectively. The RTD must also avoid internal heating due to excess power from a high lead current. If extra heat cannot be dissipated, heating caused by excitation current can raise the temperature of the sensing element above the ambient temperature causing error due to a change in resistance of the RTD. A 100 ohm RTD element has a recommended maximum operating current of 1mA.

Electronic stethoscopes can be quite costly as the technology put into them are more advanced than other devices. Prices range from $125-600, possibly lower, but only a simple electronic stethoscope will suffice. This really brings budget into the engineering design but we felt that an electronic stethoscope will perform the best in our system. Electronic stethoscopes

have longevity and sustainability as they are well put together pieces of technology and according to Joshua Schwimmer is rapidly decreasing in prices. If we could somehow incorporate a universal clip for all electronic stethoscopes to purchase a stethoscope on an as needed basis will dramatically decrease the cost by having the patients shop for their own or not have to purchase one at all. Also according to Josh, "an electronic stethoscope saves you more than a second per patient" if you see 20 patients a day. This makes sense in the clinic as a doctor when they perform physicals they are essentially passing a test on a patient who with better instruments the patient has a better chance of passing. Other constraints with electronic stethoscopes are noise from powerful cellphones or computers which may interfere with the electronic properties of the stethoscope but shouldn't pose much of a problem as the signal is sent via wire first instead of wirelessly. Also, at home patients will not need much experience with stethoscopes as conventional acoustic stethoscopes require practice and medical knowledge while these electronic stethoscopes are easier to use. Lastly, purchasing premade electronic stethoscopes saves manufacturing time as they are quite complicated to make.

The last sensor to be examined is the scale. Questions on this device involve whether or not we should include a Bluetooth enabled scale with the product or should we let the patient/physician purchase a separate scale and involve that into the overall scheme of things. If we let customers buy their own, that would save a lot of cost on manufacturing as we won't have to purchase a Bluetooth enabled scale or fit a scale with a Bluetooth device and microcontroller. Prices of premade Bluetooth enabled scales range from $35 to $250.

http://www.healthline.com/health-blogs/tech-medicine/your-next-stethoscope-should-be-electronic-heres-why-littmann-electroni

4. Safety Issues: (1 pg min) [JAKE]

Safety is always a primary concern when dealing with patients as they are already in a less than normal state and with our monitor, it will hopefully be used by a numerous amount of patients with varying states of health and/or disease ranging from cancer, heart disease, infection, trauma, and other medical uses. No device is perfectly safe as people manage to harm themselves accidentally in strange ways and we must account for these odd variables. We will try to minimize hazardous design as much as possible.

Devices that contain electrical elements always will pose a safety issue. Current should be limited around the strap with a low yet usable voltage. Each sensor must have an adequate power source (through the single wire) and contact with skin, so one safety issue is the contact with skin posing an electrocution problem and can be minimized by insulating material surrounding contacts (besides the skin) and the voltage leading to the sensors. Infrared radiation from the pulse oximeter is also a possibility which may have a harmful effect and will be noted to the patient. Coinciding with electricity and radiation, these elements can heat up therefore material that dissipates heat is desired to not burn patient's skin.

Since each sensor will be removable via clip, there can be potentially small parts that can be hazardous to infants. There will be a warning label and possibly a case that can house each sensor is possible. Another mechanical issue is the clips in itself they can pinch and perhaps pierce patient's skin.

Materials are important in design as they are in direct contact with skin and clothing. Safety hazards with the materials are scratching, skin irritation, allergic reaction, and immune response among others. Our device will be made out of material that will avoid all of these potential hazards as well as a sweat resistant, elastic, soft, breathable material on the side closest to the body and nothing abrasive to rip or tear through clothing that the patient will wear on the outside.

5. Impact of Engineering Solutions: (1 pg min)

This vital signs monitor will have the opportunity to become a solution to many global, economic, environmental, and societal problems which are prevalent today by providing an inexpensive way to monitor the heart using an ECG, body temperature, blood oxygen level, weight, and detect falls in the case of an emergency. The goal of this project is to make an efficient vital signs monitor that emphasizes on accuracy and economic accessibility. As health care remains a significant issue here in the United States and the rest of the world, an inexpensive vital signs monitor will enhance each individual's ability to understand their health, improve their well-being, and collaborate with their caretakers through the quick and easy transmission of vital data in real time. Patients suffering from numerous different conditions will attain the ability to properly monitor themselves outside of a hospital or doctor's office while simultaneously providing their caretakers with data to progress their health over time and in several different circumstances of daily life.

Providing an inexpensive vital signs monitor allows many members of society which struggle economically to assess their health at home and eliminates many unnecessary doctor or emergency room visits which can become extremely costly. This product improves the process of diagnosing conditions, doctor evaluations, self-evaluations, and examining health progress over time. With the ability to transfer information wirelessly from the biosensors on the patient's body to LabVIEW on the Microsoft Surface for processing to any internet platform for the viewing of the patient, their family, their doctors, and other caretakers the time it takes to diagnose and assess a problem will be less than the patient's time spent in the waiting room.

This project is capable of having a global effect due to its compatibility and portability. The Microsoft Surface will be available worldwide following its release date allowing our vital signs monitor to be relevant all over the globe. With the global economy suffering, revolutionizing basic vital signs monitoring with our relatively inexpensive device can result in many people being provided with proper health care whom normally could not receive the proper attention.

Our efficient vital signs monitor design stresses environmental responsibility through the limited use of materials, elimination of waste by making each biosensor capable of clipping on and off the base chest strap, and limited power usage due to our effective circuit designs in order to use the absolute minimum amount of energy possible. Making each biosensor individual with the clip-on system is an advantage for consumers and environmentalists as it reduces the waste in the event of a sensor error or malfunction. If one biosensor malfunctions, instead of needing to replace the entire chest strap, the patient need only replace the specific biosensor which no longer works accurately.

6. Lifelong Learning:

This device will take advantage of a simple and modular design that will allow future development to continue to add to the existing project with a simple hardware interface. This will provide an easy template and route of thinking that makes it easy for future engineers to design around our work without it presenting a major obstacle in functionality of the device. This is an important skill to learn because we feel that starting to work on a project with existing progress is frustrating because it requires new engineers with different ideas and experiences to conform to existing limitations and blind spots. While we don't presume that our design doesn't have such problems, we feel that the open ended format we have presented allows for the greatest amount of expansion, considering that beyond offering a platform that provides power, and a means of transmitting data, there are no restrictions or adjustments that need to be made to existing sensors to make new sensors work alongside future developments, indeed the way we plan to implement our one wire communication array is built on the assumption that there may need to be a variable amount of sensors and future devices attached to the same product.

Currently, we are all learning about the internal design of medical devices, as we continue to design these components, we will move from modeling to making the actual device, when we will run into a better idea of the software to hardware constraints. Since we intend to make the sensors out of the smallest microchips we can program to keep them light, we might run into memory issues that are currently unforeseen.

7. References:

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